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NATIONAL DAM SAFETY PROGRAM. BLUES POND DAM (MO 31538), OSAGE ---ETC(U)

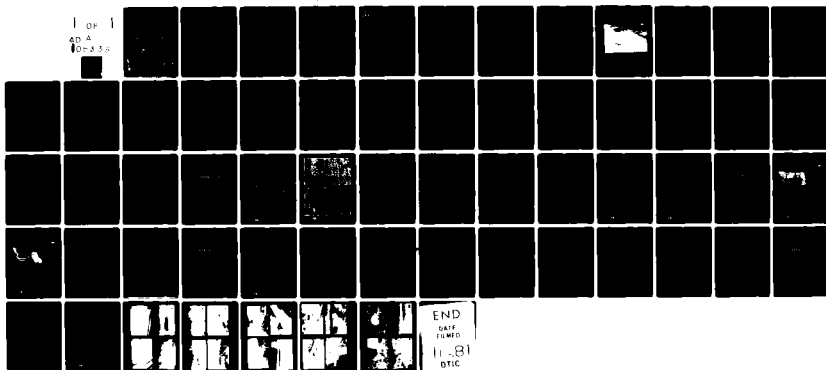
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LEVEL II



OSAGE-GASCONADE RIVER BASIN

AD A105339

BLUES POND

PHELPS COUNTY, MISSOURI

MO 31538

**PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM**



**United States Army
Corps of Engineers**

*...Serving the Army
...Serving the Nation*

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

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ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Blues Pond Dam (MO 31538)

This report presents the results of field inspection and evaluation of the Blues Pond Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY:

SIGNED

Chief, Engineering Division

8 SEP 1980

Date

APPROVED BY:

SIGNED

Colonel, CE, District Engineer

8 SEP 1980

Date

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OSAGE-GASCONADE RIVER BASIN

BLUES POND DAM

PHELPS COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31538

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

August 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam:	Blues Pond Dam
State Located:	Missouri
County Located:	Phelps
Stream:	Tributary of Little Beaver Creek
Date of Inspection:	22 May 1980

Blues Pond Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri, and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

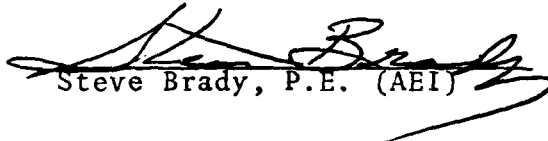
The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are an interstate highway (I-44), seven dwellings, one business, and two buildings. The existence of these downstream features was verified during the field inspection and at the time the aerial photographs were taken. The dam is in the small size classification, since it is less than 40 ft high, and the maximum storage capacity is greater than 50 acre-ft but less than 1,000 acre-ft.

Our inspection and evaluation indicates that the spillway does meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass 70 percent of the Probable Maximum Flood (PMF) without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the low height of the dam (23 ft) and the low reservoir storage capacity, 50 percent of the PMF has

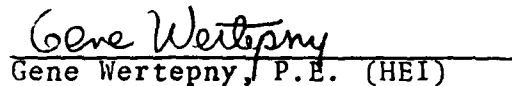
been determined to be the appropriate spillway design flood. The 1 percent probability flood will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year.

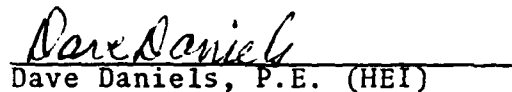
Deficiencies visually observed by the inspection team were: (1) erosion on the upstream face due to lack of wave protection; (2) tree and brush growth on the dam, especially on the downstream face; (3) a few small animal holes on both faces of the dam; (4) a minor slough on the downstream face; (5) cracking and undermining of the spillway slab; (6) a small leak through the bedrock below the spillway slab; and (7) lack of erosion protection in the spillway approach area. Another deficiency was the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action promptly to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.


Steve Brady, P.E. (AEI)


Tom Beckley, P.E. (AEI)


Gene Wertepny, P.E. (HEI)


Dave Daniels, P.E. (HEI)



AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
BLUES POND DAM - ID No. 31538

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-567, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Blues Pond Dam in Phelps County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Blues Pond Dam is an earth fill structure approximately 23 ft high and 485 ft long at the crest. In this report, right and left orientation is based on looking in the downstream direction. The appurtenant works consist of a concrete paved trapezoidal cut spillway in the left abutment. A dewatering structure consisting of a 12 in. diameter corrugated metal pipe (CMP) under the dam is located at approximate Station 3+70. Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankment. Presented on Sheet 4 of Appendix A are a profile and section of the spillway.

B. Location:

The dam is located in the north central part of Phelps County, Missouri, on a tributary of Little Beaver Creek. The dam and lake are within the Rolla, Missouri, 7.5 minute quadrangle sheet (Section 9, T37N, R8W - latitude 37°36.3'; longitude 91°48.4'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 23 ft and a maximum storage capacity of approximately 113 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are an interstate highway (I-44), seven dwellings, one business, and two buildings. The existence of these downstream features was verified during the field inspection and at the time the aerial photographs were taken.

E. Ownership:

The dam is owned by Murray Renick, 1115 Duane Avenue, Rolla, Missouri, 65401 (telephone 314-364-1786) and J. F. Brenneisen, 1103 Joyce, Rolla, Missouri, 65401 (telephone 314-364-3175).

F. Purpose of Dam:

The dam was constructed primarily for recreation.

G. Design and Construction History:

According to Mr. Renick, the dam was originally built in 1955 by Mr. Luther Mathis of Newburg, Missouri. The lake was drained for enlargement in 1959. The lake was enlarged by raising the height of the dam 3 ft and by excavating material from the upper reaches of the lake. The material excavated was used as fill for the Holiday Inn, which is located just upstream of the lake. The spillway was raised about 6 in. at this time, and a concrete section was placed.

A 12 in. diameter corrugated metal pipe dewatering structure was also constructed at this time. According to Mr. Renick, the 12 in. CMP has a concrete foundation at its entrance invert and a slide gate at the upstream end which could be raised by attaching to it under water and then hoisting from above. Also, apparently installed at that time, was a 2 1/2 in. steel pipe with a nut valve on the downstream end. There are no plans or design calculations available and, to our knowledge, no modifications have been made since 1959.

H. Normal Operating Procedures:

Normal flows are discharged through an uncontrolled trapezoidal spillway in the left abutment. The owner indicated that the lake maintains a relatively constant level and that he has never seen it lower than about 1 ft below the spillway crest. The owner also indicated that the dam has never overtopped, and that he has never seen water more than 1 ft above the spillway crest.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile, and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the USGS quad sheet, is approximately 200 acres.

B. Discharge at Dam Site:

- (1) All discharge at the dam site is through an uncontrolled spillway.
- (2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 922.3): 1,600 cfs
- (3) Estimated Capacity of Primary Spillway: 1,600 cfs
- (4) Estimated Experienced Maximum Flood at Dam Site: 74 cfs
- (5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable
- (6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable
- (7) Gated Spillway Capacity at Pool Elevation: Not Applicable
- (8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level (MSL) elevation of 917.7 for the spillway crest (estimated from quadrangle map).

- (1) Top of Dam: 922.3 (low point); 923.0 (high point)

- (2) Principal Spillway Crest: 917.7
- (3) Emergency Spillway Crest: Not Applicable
- (4) Principal Outlet Pipe Invert: Not Applicable
- (5) Streambed at Centerline of Dam: 900.5
- (6) Pool on Date of Inspection: 917.5
- (7) Apparent High Water Mark: None Found
- (8) Maximum Tailwater: Unknown
- (9) Upstream Portal Invert Diversion Tunnel: Not Applicable
- (10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

- (1) At Top of Dam: 1,400 ft
- (2) At Principal Spillway Crest: 1,100 ft
- (3) At Emergency Spillway Crest: Not Applicable

E. Storage Capacities:

- (1) At Principal Spillway Crest: 46 acre-ft
- (2) At Top of Dam: 113 acre-ft
- (3) At Emergency Spillway Crest: Not Applicable

F. Reservoir Surface Areas:

- (1) At Principal Spillway Crest: 8 acres
- (2) At Top of Dam: 18 acres
- (3) At Emergency Spillway Crest: Not Applicable

G. Dam:

- (1) Type: Earth
- (2) Length at Crest: 485 ft
- (3) Height: 22.5 ft
- (4) Top Width: 13 ft

- (5) Side Slopes: Upstream 2.4:1; Downstream 1.9:1
- (6) Zoning: Homogeneous
- (7) Impervious Core: Unknown
- (8) Cutoff: Unknown
- (9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

- (1) Type: Not Applicable
- (2) Length: Not Applicable
- (3) Closure: Not Applicable
- (4) Access: Not Applicable
- (5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

- (1) Location: Left Abutment
- (2) Type: Trapezoidal Cut with Concrete Paving

I.2 Emergency Spillway:

- (1) Location: Not Applicable
- (2) Type: Not Applicable

J. Regulating Outlets:

The only regulating outlets are two drawdown pipes under the dam. The owner indicated that these pipes were installed in 1959 when the lake was enlarged and the dam was raised. The 12 in. CMP reportedly has a steel slide gate at the upstream end which could be raised by attaching to it under water and then hoisting from above. The 2 1/2 in. steel pipe has a nut valve on the downstream end. To our knowledge, neither pipe has been used since 1959.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No design computations or reports for Blues Pond Dam are available. No documentations of construction inspection records were obtained. To our knowledge, there are no documented maintenance data. An Engineering Geologic Report of Blue Lake by the Missouri Department of Natural Resources dated October 1977 is included as Sheets 3 and 4 of Appendix B.

A. Surveys:

No information regarding pre-construction surveys was available. The crest of the spillway was used as datum for the inspection survey and assumed to be at elevation 917.7 (estimated from the USGS quadrangle).

B. Geology and Subsurface Materials:

The site is located in the central portion of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus, and deep valleys. The most common bedrock types are dolomite, sandstone, and chert.

The publication "The Geology of the Rolla Quadrangle" indicates that the bedrock in the area of the dam and lake is the Roubidoux formation of the Canadian Series in the Ordovician System. The Roubidoux formation is the most widely exposed formation in the Rolla quadrangle, and consists of sandstone, dolomitic sandstone, and cherty dolomite. The beds of the Roubidoux are, as a whole, nonresistant to weathering. Consisting of alternating thin beds of chert, quartzite, sandstone, and thin-bedded dolomites, the formation is easily broken down. An Engineering Geologic Report of Blues Pond by the Missouri Department of Natural Resources indicates that "sandstone and cherty dolomite of the Roubidoux Formation make up the lake basin with dolomite of the Jefferson City-Cotler Formation making up the drainage area." The complete report is included as Sheets 3 and 4 of Appendix B.

The publication "Caves of Missouri" indicates that at least 56 caves exist in Phelps County. Of these caves, at least five caves are located in the Rolla quadrangle, and eleven caves are in the adjacent Yancy Mills quadrangle. All of the 14 caves which are within ten miles of the site are clustered to the west and southwest.

The "Geologic Map of Missouri" indicates several normal faults about 30 miles east and northeast of the site. The Missouri Geological Survey has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years.

Information from the United States Department of Agriculture, Soil Conservation Service indicates that soils in the watershed area of Blues Pond are comprised of the following soil types:

<u>Soil (Slopes)</u>	<u>Percent of Watershed</u>
Bardley (5-9%)	33
Bardley (9-14%)	62
Hartville (0-2%)	5

The Bardley soils typically have dark brown cherty silt loam A-horizons and red silty clay and clay B-horizons and are underlain by bedrock at depths of 20 to 40 in. The Bardley soils are on gently sloping ridges and strongly sloping to steep side slopes. They have formed in residuum from cherty dolomite interbedded with some limestone and sandstone.

The Hartville soils are generally silt loams for the upper 14 in. and silty clay and clay below that, and are underlain by a cherty clay at a depth of 5 ft to 6 ft. The Hartville soils are typically poorly drained soils on alluvial terraces.

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analyses apparently were not performed as required in the guidelines. It is anticipated that the dam is homogeneous without any internal drainage features. The material is probably primarily silts and clays taken from the lake area. It is not known whether a cutoff trench was provided. No construction inspection tests were available.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for this dam were available. Based on a field check of spillway dimensions and embankment elevations, and a check of the drainage area on USGS quad sheets, hydrologic analyses using U.S. Army Corps of Engineers guidelines were performed and appear in Appendix C, Sheets 1 to 9.

E. Structure:

No design information for appurtenant structures was available.

2.2 CONSTRUCTION:

No construction inspection data were available.

2.3 OPERATION:

Normal flows are discharged through an uncontrolled concrete paved trapezoidal cut spillway in the left abutment. The only regulating facilities are the two drawdown pipes (one 12 in. CMP and one 2 1/2 in. steel) under the dam. To our knowledge, these pipes have not been used since 1959.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

3. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on 22 May 1980. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri, and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steve Brady - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)
Gene Wertepny - Hanson Engineers, Inc. (Hydraulic Engineer)
Dave Daniels - Hanson Engineers, Inc. (Geotechnical Engineer)

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The dam appears to be in less than satisfactory condition. The upstream face is grass covered; however, there is no riprap protection. Some bank erosion and several small sloughs caused by wave action and saturation have occurred. A few small animal holes were noted. The horizontal alignment of the crest appeared good, and no surface cracking or unusual movement was obvious (see Photos 4 and 5).

The downstream face is moderately covered with trees and brush and is fairly steep (survey indicates slopes between 1.7 and 2 horizontal to 1.0 vertical). A small slough was noted near the crest at approximate Station 3+00. A few small animal holes were noted. No seepage was noted at the base or through the dam. Shallow auger probes in the dam encountered a brown clayey silt to silty clay material (ML-CL). Photo No. 6 shows the downstream face. Sheet 5 of Appendix A presents a plan sketch of the dam showing observed features.

C. Appurtenant Structures:

C.1 Primary Spillway:

The spillway is a trapezoidal cut in the left abutment with concrete paving in the upper portions of the spillway (see Photos 7 through 15). The slab has experienced some cracking, and a hole in the slab was noted as shown in Photo No. 12. Apparently, water is entering the hole and causing some undermining of the slab. A pile of concrete rubble and rock was placed on the right side of the slab downstream of the hole (see Photo No. 13) in an apparent effort to reduce soil loss from under the slab. Some grading has been done recently in the approach area of the spillway on the dam side. This area would appear to be

susceptible to erosion during floods. A small seep ($\pm 1/2$ GPM) was noted below the end of the concrete paving and was apparently coming through the bedrock. There was no evidence of soil being carried with the water. The owner indicated that this seep has been there for many years (see Photo No. 15).

C.2 Emergency Spillway:

There is no emergency spillway.

C.3 Drawdown Pipes:

A 12 in. CMP drawdown pipe was installed in 1959, but according to the owner, it has never been used. A slide gate is incorporated at the entrance, but would have to be opened by divers. The exit end (see Photo No. 18) appeared in good condition, and no water was seen in or around the pipe. A 2 1/2 in. steel pipe was also seen about 12 ft right of the 12 in. pipe (see Photo No. 19). The steel pipe has a nut valve on the end and, according to the owner, was probably also installed in 1959. No water was seen around the smaller pipe.

Because the valve of the 2 1/2 in. drain is located on the downstream side of the dam, the full head of water impounded by the dam is acting entirely through the dam. The area around the lake drain outlet should be periodically inspected for seepage which might indicate a leak or rupture of the drain pipe and could eventually initiate a piping failure through the embankment.

D. Reservoir:

The watershed is mostly grass and agricultural land with some patches of fairly dense woods. About 20 acres of the watershed are terraced, and 6 acres drain from concrete surfaces. The slopes adjacent to the reservoir are moderate, and no sloughing or serious erosion was noted. No evidence of significant sedimentation was observed.

E. Downstream Channel:

Spillway flows cascade down the left abutment area on sandstone and dolomite bedrock (see Photo No. 14) and through a roadway culvert immediately downstream of the dam (see Photo No. 16). Spillway releases would not be expected to endanger the dam. The roadway culvert has been seriously undermined by spillway releases (see Photo No. 17). Beyond the roadway, the valley is fairly wide, and the channel is fairly densely wooded on both sides.

3.2 EVALUATION:

Trees and brush on the dam constitute a potential seepage hazard and encourage animal burrowing. There is no wave protection provided for the upstream face of the embankment, and significant bank erosion and some sloughing has occurred.

The approach area on the dam side of the spillway is unprotected and will experience erosion during significant floods. The spillway slab has some cracks, holes, and apparent undermining. This condition will worsen unless voids under the slab are grouted, and holes and cracks are sealed. The seep through the bedrock in the spillway area could increase and should be monitored.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no operating facilities associated with this dam. The pool is normally controlled by rainfall, runoff, evaporation, the capacity of the uncontrolled spillway, and apparent leakage from the reservoir. The drawdown pipes have not been operated for many years.

4.2 MAINTENANCE OF DAM:

The crest and the upstream face were clear on the day of the inspection. Apparently, there is no other regular maintenance.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities, except for the slide gate for the 12 in. CMP, which is under water and has no above-water stem.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The vegetation on the dam, animal holes, lack of riprap, and deterioration of the spillway slab are deficiencies which could become serious if repairs are not made and regular maintenance is not provided.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic design computations for this dam were available.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed. The owner indicated that the lake maintains a relatively constant level, and that he has never seen it lower than about 1 ft below the spillway crest. The owner also indicated that the dam has never overtopped, and that he has never seen water more than 1 ft above the spillway crest.

C. Visual Observations:

The spillway slab has experienced some cracking and undermining. The approach area is unprotected on the dam side and would be susceptible to erosion. A small seep (+ 1/2 gpm) was noted in the spillway below the end of the slab and is apparently coming through the bedrock. The spillway outlet channel is well separated from the embankment, and spillway releases would not be expected to endanger the dam.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U.S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the reservoir storage and the pool and drainage areas from the Rolla, Missouri, 7.5 Minute USGS quad sheet.

Based on the hydrologic and hydraulic analyses presented in Appendix C, the spillway will pass 70 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the low height of the dam (23 ft) and the low storage capacity (113 acre-ft) of the lake, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillway will pass the 1 percent probability flood without overtopping the dam.

Application of the Probable Maximum Precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 3,592 cfs. For 50 percent of the PMP, the peak inflow was 1,796 cfs.

The routing of the PMF through the spillway and dam indicates that the dam will be overtopped by 0.8 ft at elevation 923.1. The duration of the overtopping will be 0.6 hours, and the maximum outflow will be 2,781 cfs. The maximum discharge capacity of the spillway is 1,600 cfs. The routing of 50 percent of the PMF indicates that the dam will not be overtopped. The maximum outflow will be 1,094 cfs. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 5.1B and 5.2.

B. Design and Construction Data:

No design and construction data for the foundation and embankment were available. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

The dam was raised 3 ft, and the concrete spillway slab was constructed in 1959. The drawdown pipes were also installed at this time. No other modifications are known to have been made since that time.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in less than satisfactory condition. Several items were noted during the visual inspection which should be investigated further, corrected, or controlled. These items are: (1) erosion on the upstream face due to lack of wave protection; (2) tree and brush growth on the dam, especially on the downstream face; (3) a few small animal holes on both faces of the dam; (4) a minor slough on the downstream face; (5) cracking and undermining of the spillway slab; (6) a small leak through the bedrock below the spillway slab; and (7) lack of erosion protection in the spillway approach area (on the dam side). Another deficiency was the lack of seepage and stability analysis records.

The dam will be overtopped by flows in excess of 70 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will continue to deteriorate and possibly could become serious in the future.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no additional inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

- (1) Our analyses indicate that the spillway size and height of dam are adequate to pass 70 percent of the PMF, which meets the requirements of the guideguidelines for this size dam.

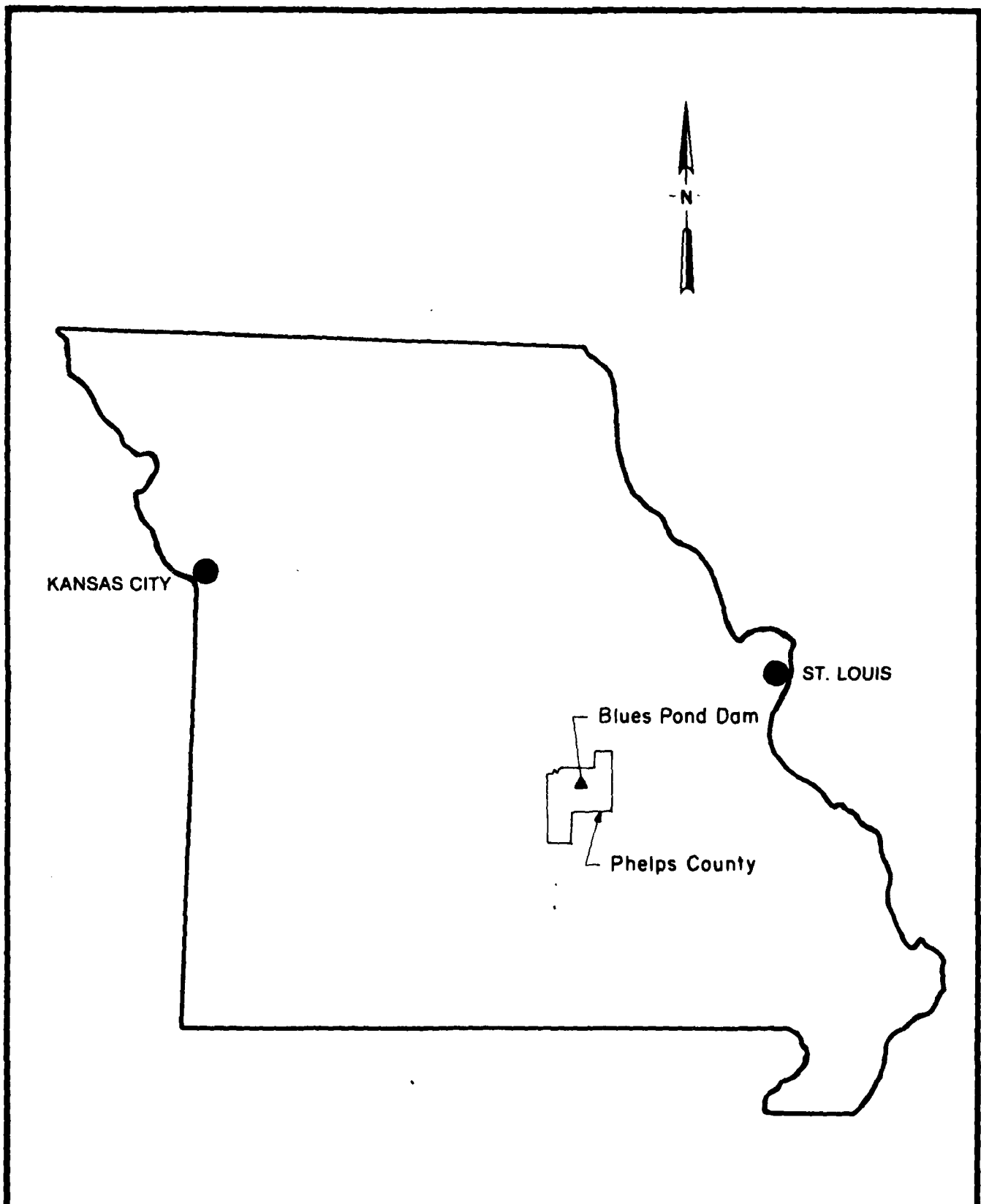
B. O&M Procedures:

- (1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.
- (2) Tree and brush growth on the dam should be cut annually.
- (3) The erosional areas on the upstream face should be repaired, and wave protection should be provided.
- (4) Animal holes should be filled and maintained.
- (5) The spillway approach area on the dam side should be provided with erosion protection.
- (6) The voids under the spillway slab should be grouted, and the holes and cracks in the slab should be sealed.
- (7) The gate for the drawdown pipe should be opened periodically to insure that it is operable.

- (8) The seep should be monitored periodically to determine if there is any increase in flow and whether soil particles are being carried with the water.
- (9) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



LOCATION MAP



**HANSON
ENGINEERS**
INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Blues Pond Dam
Phelps County, Missouri
Mo. I.D. No. 31538

SHEET 1, APPENDIX A



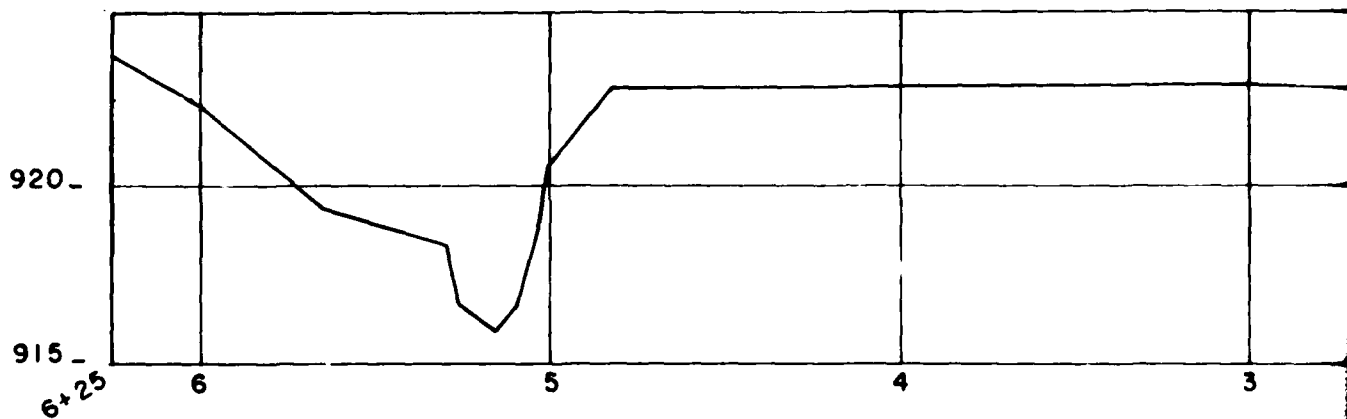
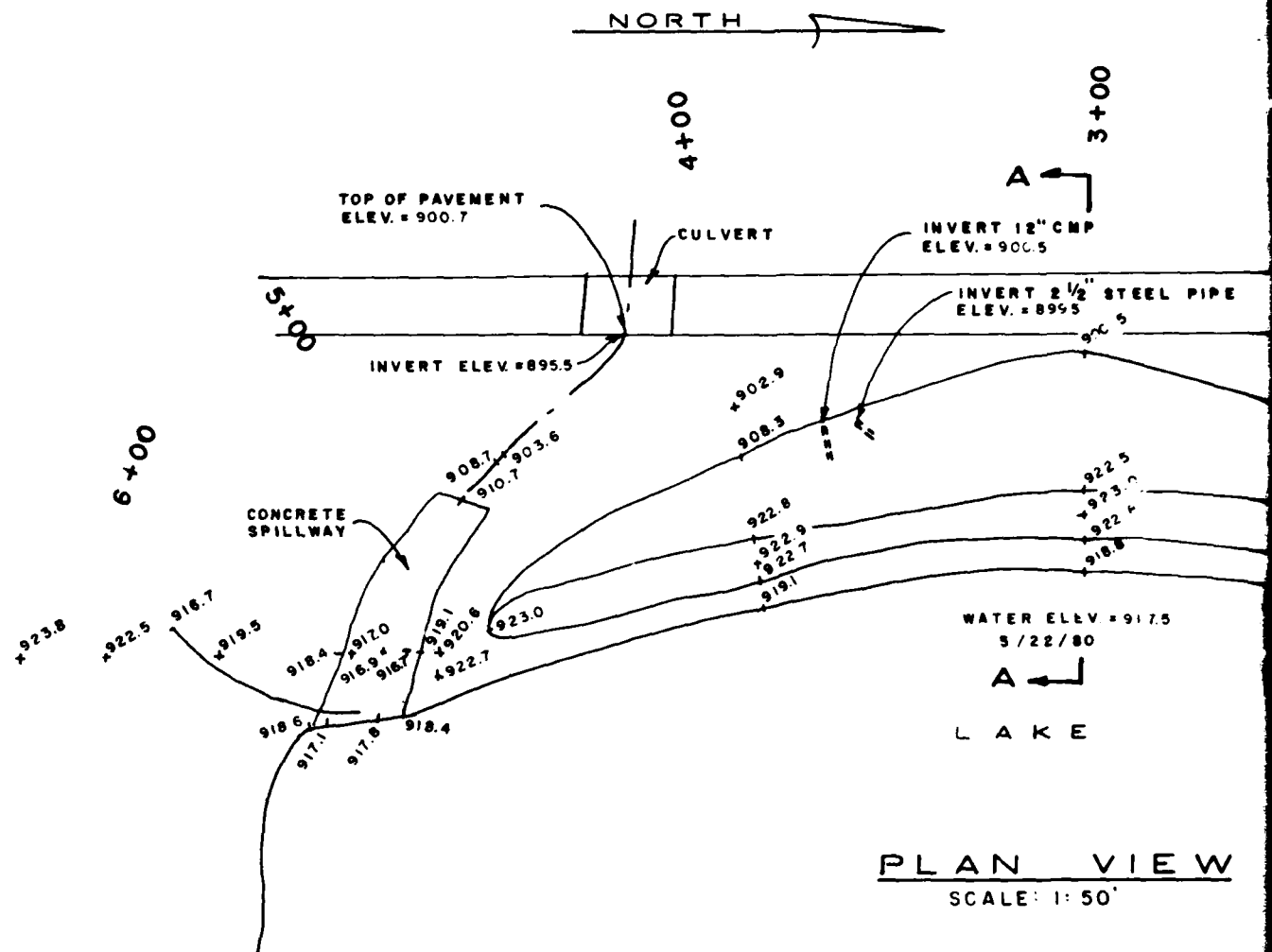
VICINITY MAP



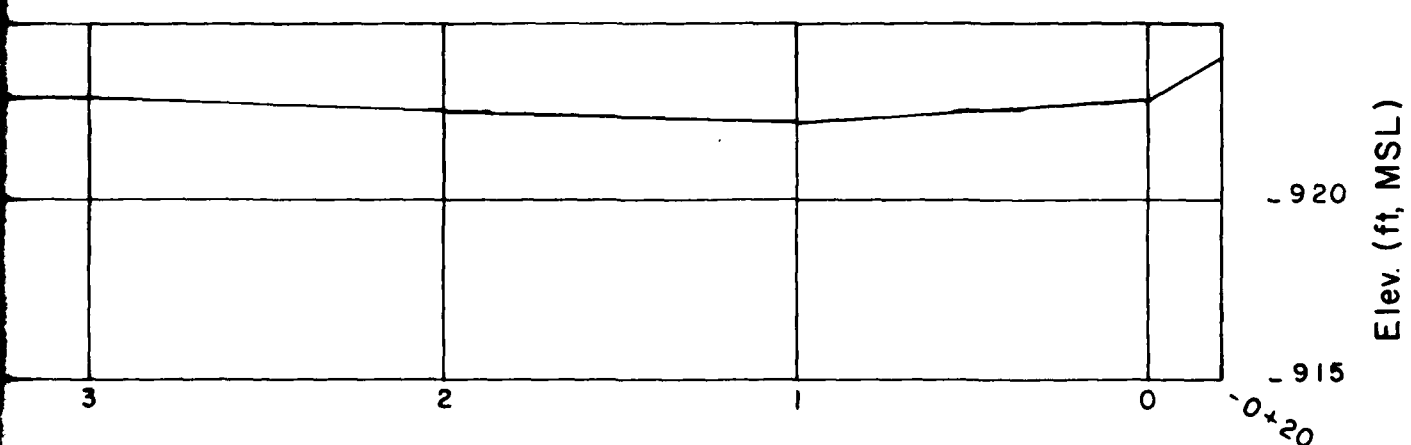
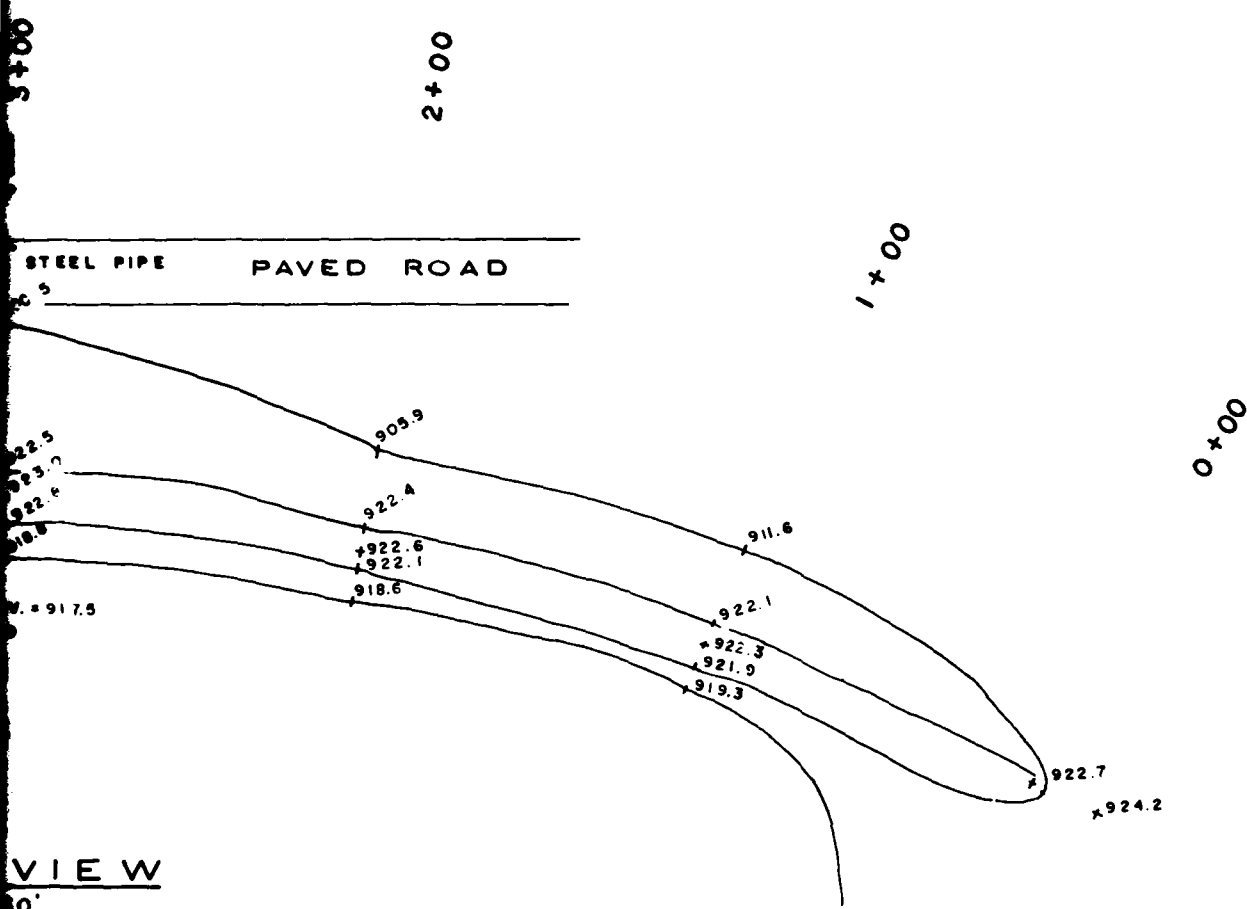
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Blues Pond Dam
Phelps County, Missouri
Mo I.D. No. 31538

Sheet 2, Appendix A

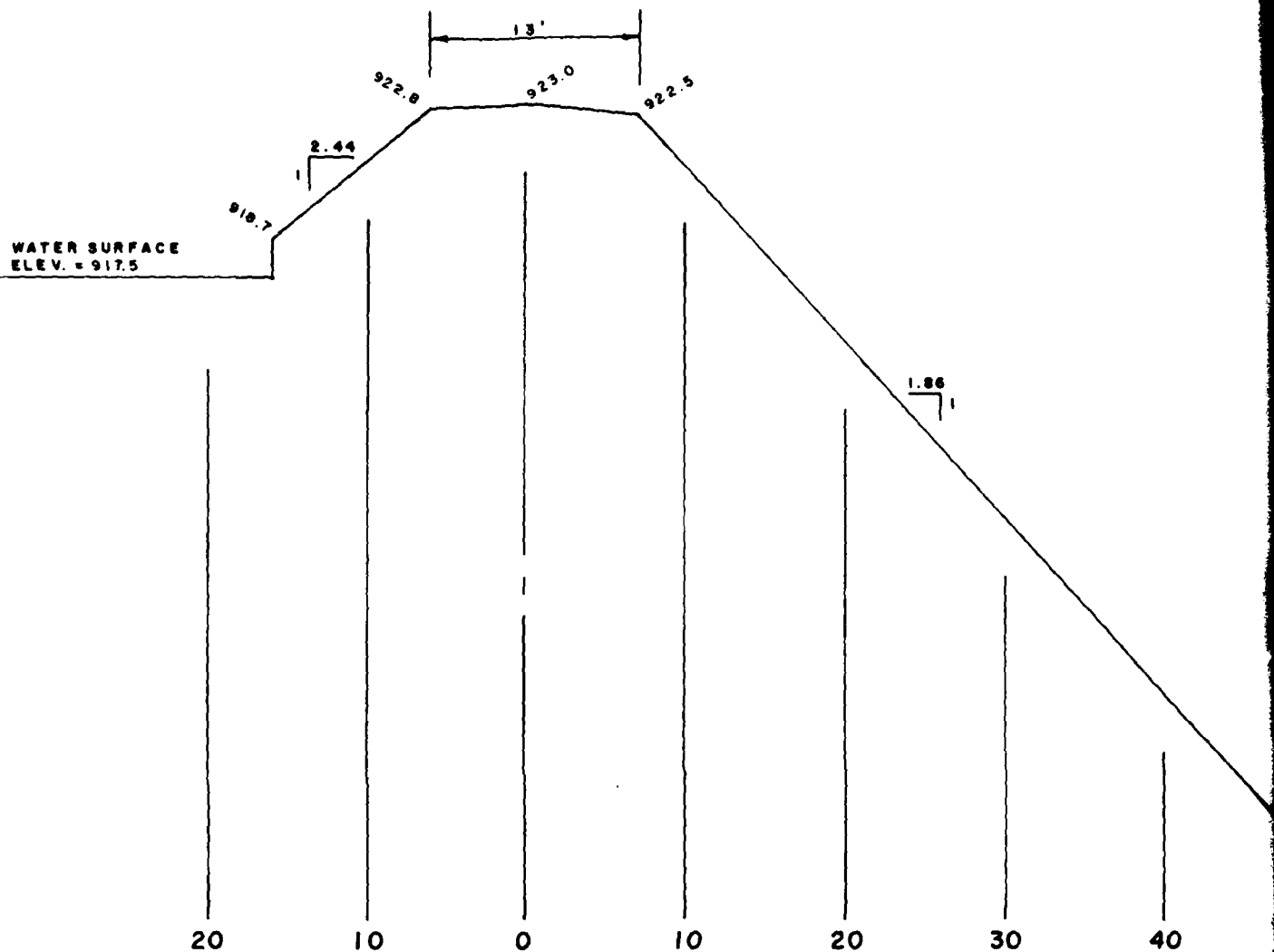


PROFIL



PROFILE

WATER
ELEV.

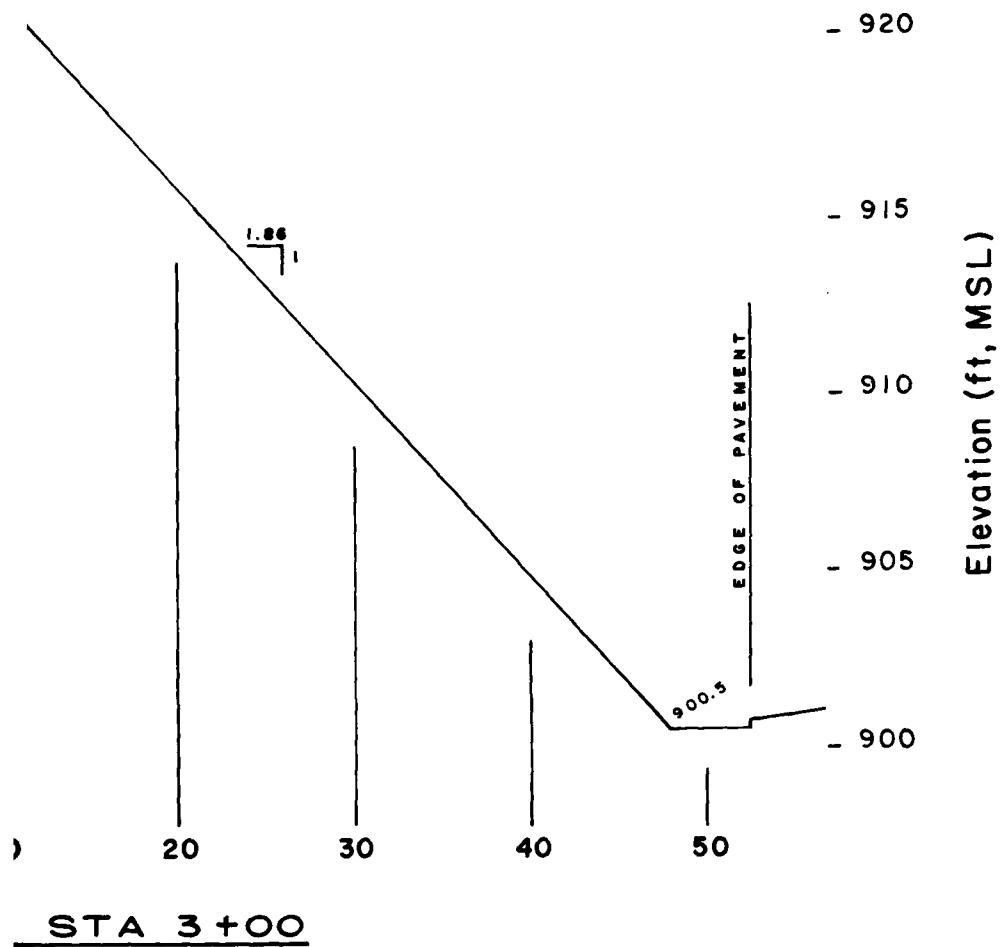


SECTION A-A STA 3+00

Elev. (ft, MSL)

SHEET
AND
100
SPRINT

13



SHEET 3 APPENDIX A

ANDERSON ENGINEERING, INC.
750 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

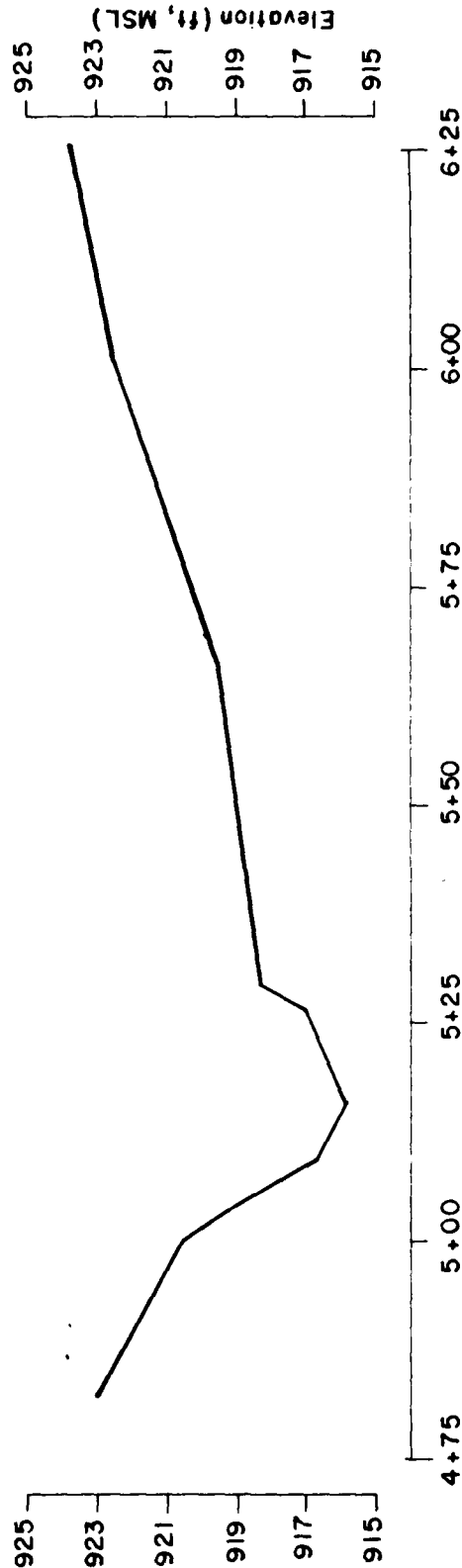
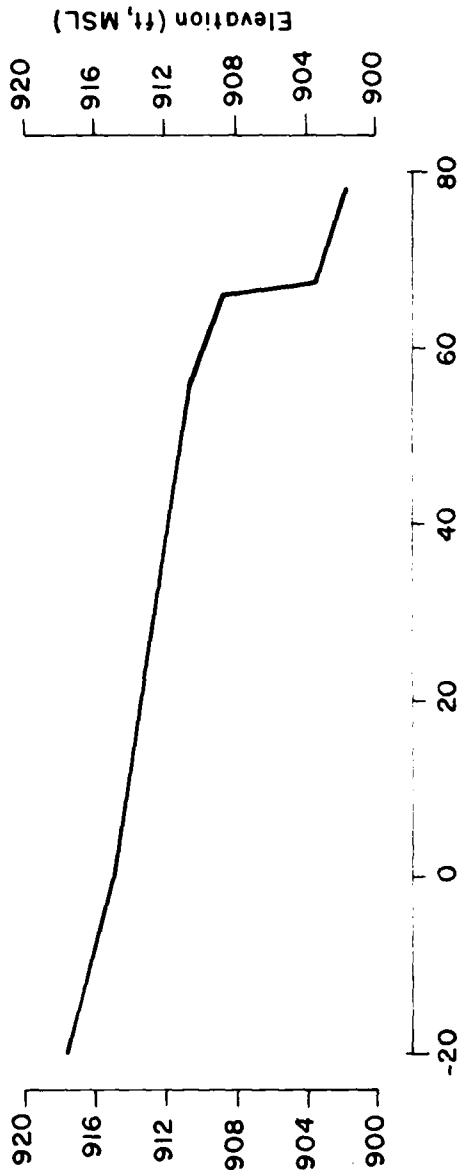
BLUES POND

MO. No. 31538

PLAN & PROFILE

PHELPS COUNTY, MO.

4



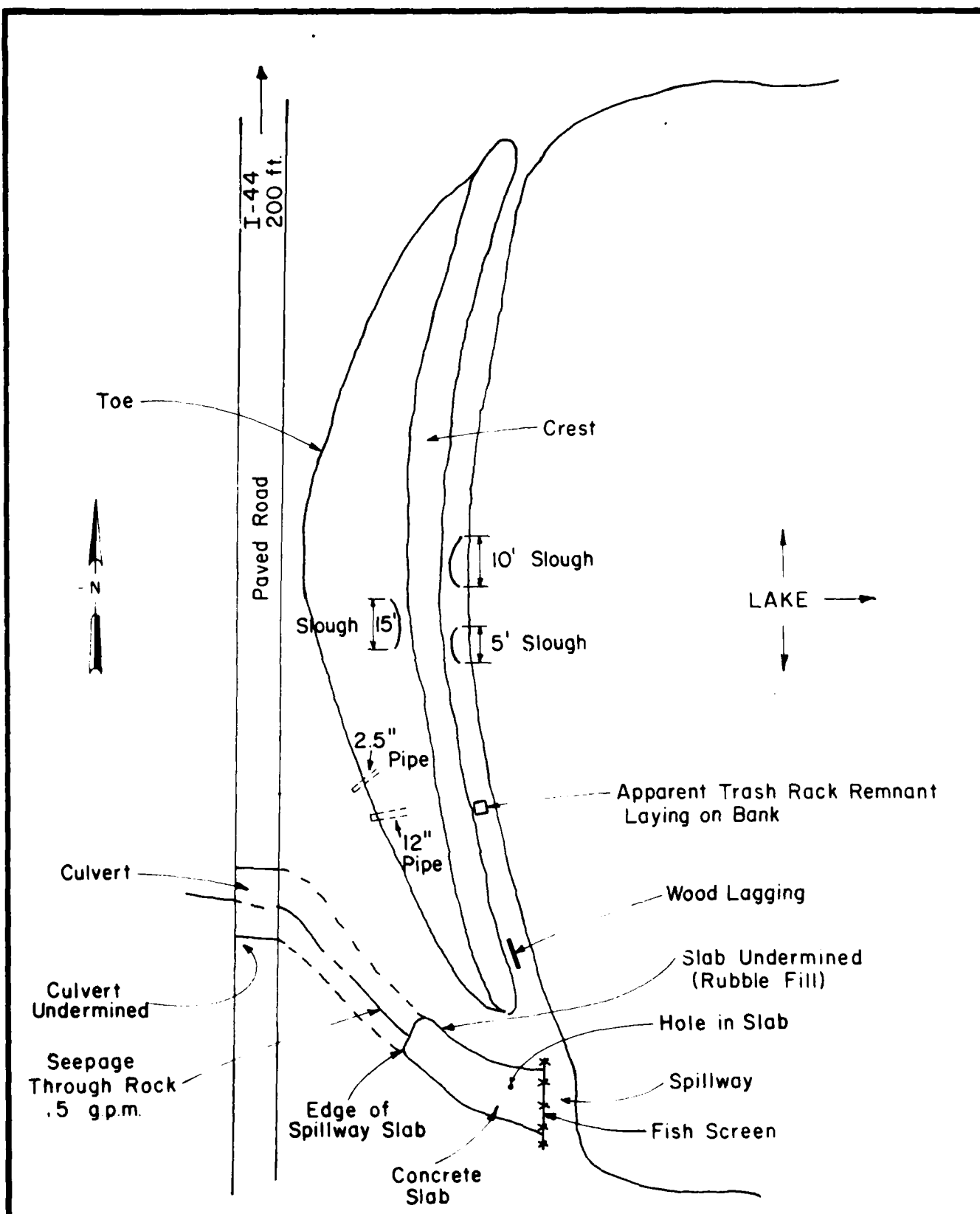
PROFILE & SECTION OF SPILLWAY



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Blues Pond Dam
Phelps County, Missouri
Mo. I.D. No. 31538

Sheet 4, Appendix A



PLAN SKETCH OF FEATURES



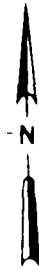
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Blues Pond Dam
Phelps County, Missouri
Mo. I.D. No. 31538

Sheet 5, Appendix A

APPENDIX B

Geology and Soils



LEGEND

GLACIATED PLAINS



WESTERN PLAINS



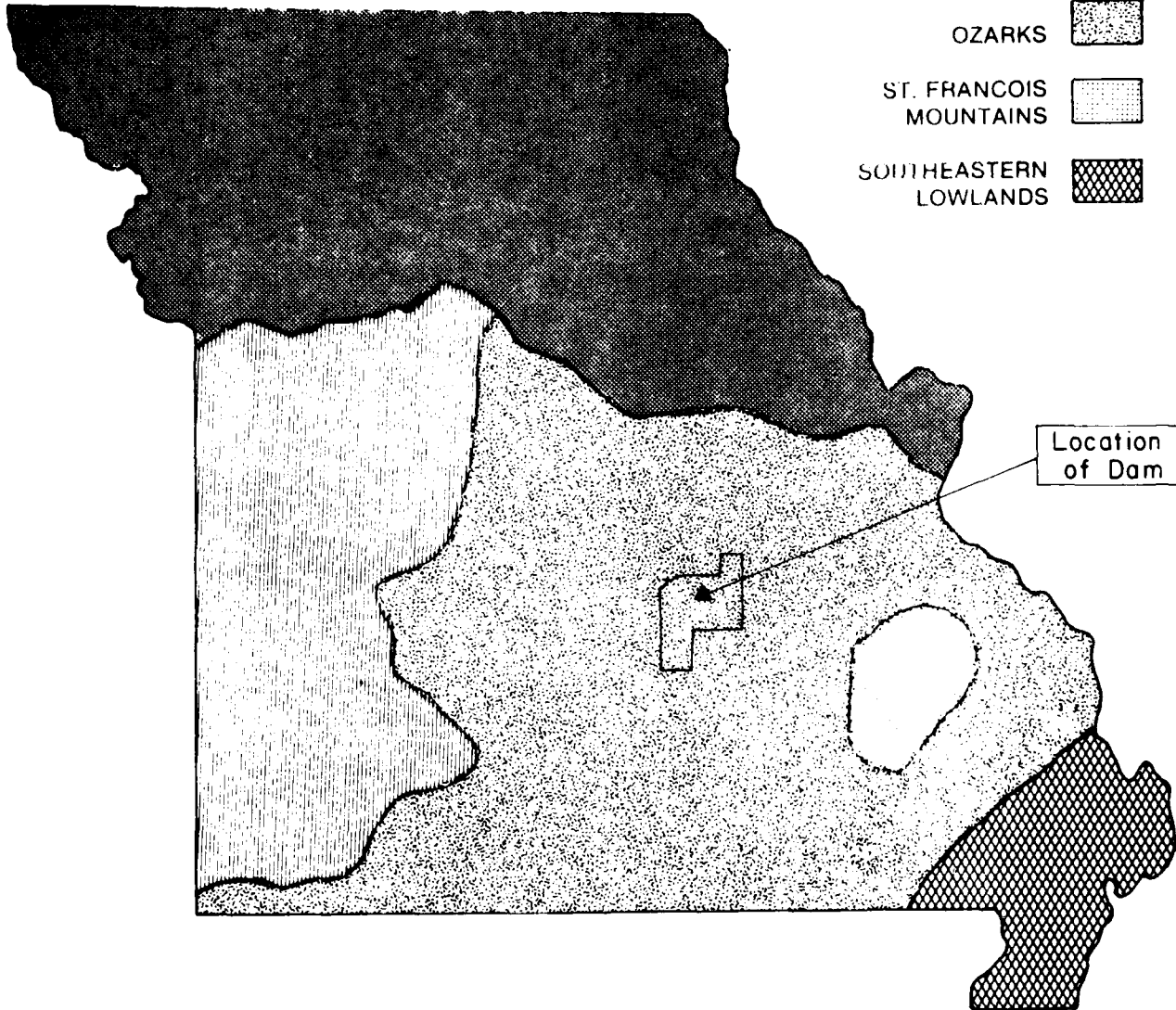
OZARKS



ST. FRANCOIS MOUNTAINS



SOUTHEASTERN LOWLANDS



Location of Dam

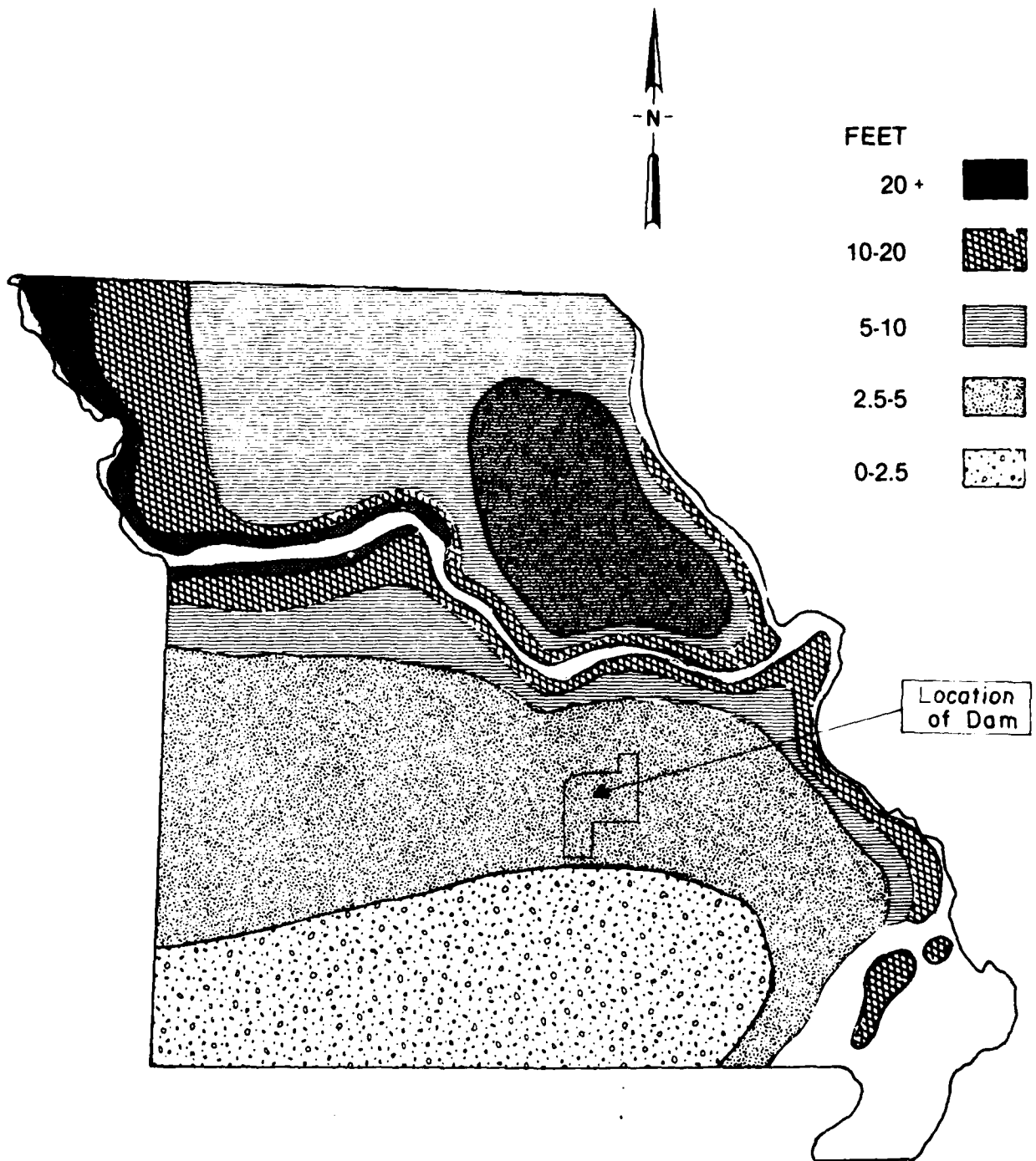
MAJOR GEOLOGIC REGIONS OF MISSOURI



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Blues Pond Dam
Phelps County, Missouri
Mo. I.D. No 31538

SHEET 1, APPENDIX B



THICKNESS OF LOESSIAL DEPOSITS



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Blues Pond Dam
Phelps County, Missouri
Mo. I.D. No. 31538

SHEET 2, APPENDIX B

BR

ENGINEERING - CIVIL - REPORT ON BEAR LAKE (CONT'D)

PHELPS COUNTY, MISSOURI

LOCATION: SE4, NE4, SE4, Sec. 9, T. 37 N., R. 8 W., Polk Quadrangle.

The lake, constructed approximately 30 years ago, is in an east-west trending tributary of Little Beaver Creek. Sandstone and cherty dolomite of the Roubidoux Formation make up the lake basin with dolomite of the Jefferson City-Cotter Formation making up the drainage area.

The sandstone portion of the Roubidoux Formation is very permeable vertically due to large cracks in the sandstone bedrock that go for a considerable depth vertically and for great distances horizontally. The bedrock exposed below the spillway of the dam is somewhat typical of the sandstone bedrock. Sufficient quantities of soil washed in off the slopes evidently have masked the bedrock to a depth sufficient to pond water in the lake, and/or the core under the dam is placed at a sufficient depth to intercept water moving through the jointed bedrock. The bedrock in the watershed in contrast is relatively water tight vertically and makes a somewhat ideal watershed in that much of the rainfall in the watershed will eventually flow into the stream and into the lake. A trickle of water into the lake would be expected on a near perennial basis either on the surface or the shallow subsurface.

The drainage area serving the lake is approximately 200 surface acres. The lake as calculated from a 1911 topographic map is between 5 and 6 acres. The drainage area is ample for the size of the lake.

A small leak that has been present for many years emanates from the base of the dam and would not be considered excessive leakage or dangerous to the dam unless soil materials start piling from this spring area. A small vertical hole has formed on the upstream portion of the spillway that is probably the result of saturated soil material flowing into one of the vertical cracks in the underlying sandstone. This vertical hole will in all probability enlarge itself with time and probably can be temporarily repaired by filling the hole with a very fluid cement material such as neat cement (a cement and water mixture with a catalyst to make the cement set up within minutes rather than hours). This type of vertical leakage can occur in this setting at any time and should be repaired as soon as possible to prevent enlargement of the hole.

The dam appears to be relatively sound considering its age although the downstream slope of the dam is excessively steep. Raising of the water level in the lake several feet in all probability would cause slides to occur on the downstream face of the dam. If the dam height were raised even several feet, it would probably be necessary to start at the base of the dam rather than increasing only the height of the top of the dam to flatten out that downstream slope. Raising of the water level of the lake even several feet may well aggravate minor leakage conditions now present and may well facilitate re-design and construction of the spillway as well as extending the end of the dam further to the south.

Expansion of the lake laterally by excavating on the shoreline as well as the tailwater area of the lake is contemplated, both for locating borrow material as a fill source for another area and to beautify the lake. Excavation along the shoreline in the low lying areas can probably be accomplished without getting into the bedrock excavation or adding to leakage conditions into bedrock. The lake, however, should not come in contact with sandstone bedrock over a large area particularly just upstream of the dam. Exposure of the lake water to the underlying bedrock would probably result in excessive leakage. Extending the shoreline of the lake horizontally in the high areas would result in a high vertical bluff on the shoreline as well as rock excavation. It is anticipated that a maximum of 4-5 feet of soil is present generally on the shoreline.

The upper end of the lake would probably have the greatest potential yield of borrow material and would increase the surface area of the lake the most for the amount of material removed. Yardage estimates for borrow material can roughly be calculated using a rule of thumb that one acre excavated 3 feet deep will yield about 4,800 cubic yards of material. This material, however, will normally shrink when it is compacted in a fill so it might take 110,000 to 115,000 thousand cubic yards to fill up a 100,000 yard hole.

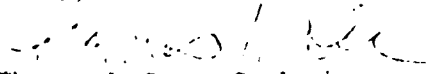
To determine whether sufficient soil material is available on the floodplain on the upper end of the lake for anticipated fill needs, it is recommended that a backhoe be employed to excavate several test pits to determine if sufficient borrow material is available and whether sufficient depth can be attained to back the water into the excavated area a sufficient depth to where the borrow pit is under water. It is recommended that a minimum of 3 feet of water cover the borrow area to prevent excessive weed growth and the formation of large mud flats in the dry summer months when the lake level could drop a foot or more because of evaporation, leakage, etc. The backhoe could also be utilized to probe the shoreline of the lake to determine thickness of soil over bedrock in other potential expansion areas. Approximately two hours time with a backhoe would be sufficient to make this determination.

Lowering of the lake level several feet would probably be necessary to expedite the excavation in the upper end of the lake as would improvements on other parts of the shoreline. A time frame necessary to lower a lake of this size several feet can be roughly calculated by assuming one acre of water one foot deep contains approximately one-third of a million gallons of water.

In summary:

1. Raising the water level may result in excessive leakage and require re-designing of the dam and spillway.
2. Borrowing material from the sides of the lake on the high areas probably will require rock excavation. The low areas would yield some earthen material.
3. Expansion of the upper end of the lake would probably yield the largest amount of borrow material.

If this office can be of further assistance, don't hesitate to call or write.

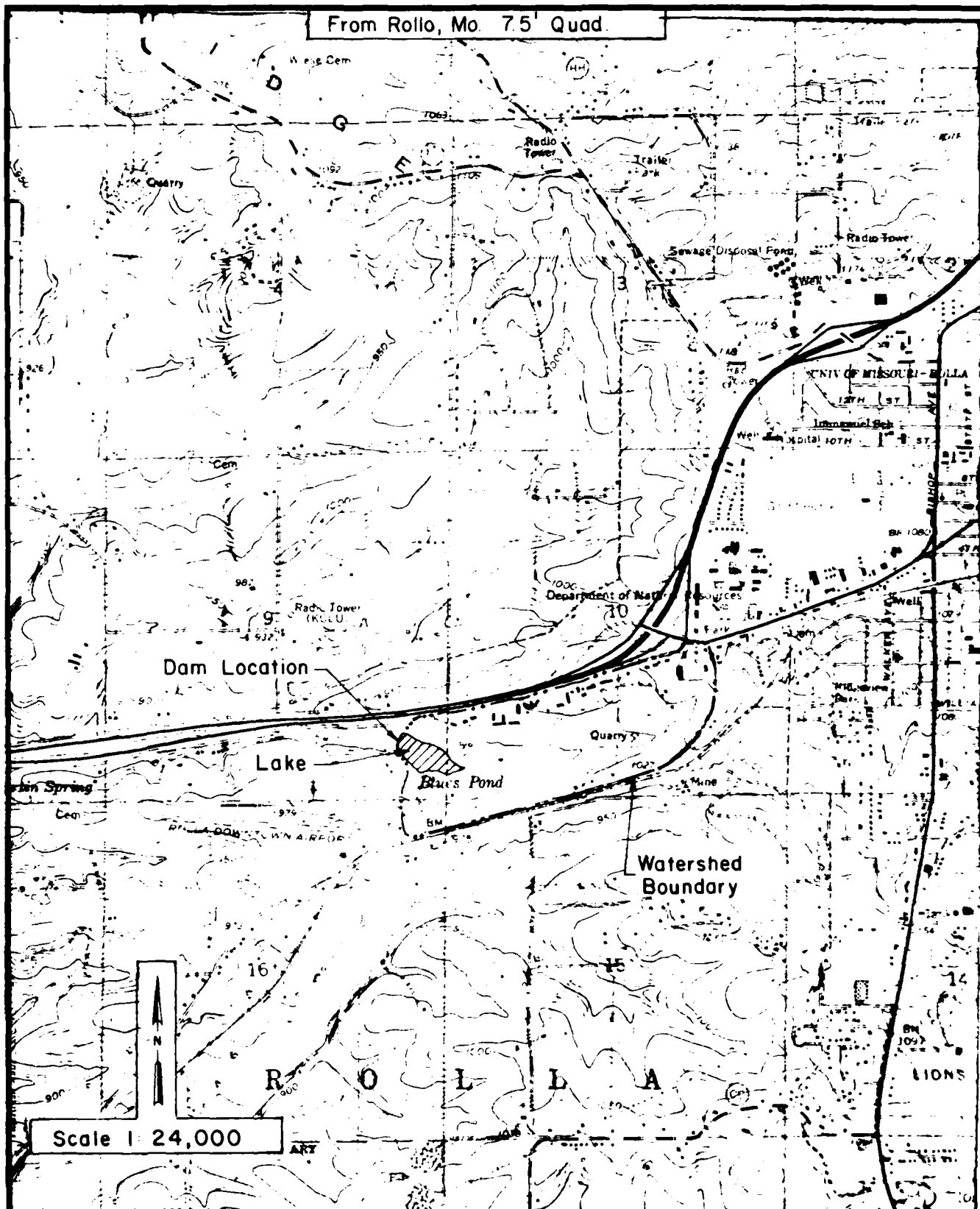

Thomas J. Dean, Geologist
Applied Engineering & Urban Geology
Geology & Land Survey
October 17, 1977

Print: Murry Penick
1115 Wayne Ave.
Bella, MO

APPENDIX C

Overtopping Analysis

From Rollo, Mo. 7.5' Quad



LAKE AND WATERSHED MAP



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Blues Pond Dam
Phelps County, Missouri
Mo. ID No 31538

Sheet I, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination).

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The parameters for the unit hydrograph are shown in Table 1 (Sheet 3, Appendix C).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2 (Sheet 4, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method assuming the starting elevation at normal pool. The hydraulic capacity of the spillway was used as an outlet control in the routing. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 4, Appendix C).

The result of the routings of the PMF ratios indicate that the dam will pass the 1 percent probability flood without overtopping the dam.

The rating curve for the spillway (see Table 4 Sheet 5, Appendix C) was determined assuming critical flow condition at the control section.

The flow over the crest of the dam during overtopping was determined using the non-level dam option (\$L and \$V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 6, Appendix C).

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 7, 8 and 9 of Appendix C.

TABLE 1
SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.31 sq miles
Length of Watercourse (L)	0.90 miles
Difference in elevation (H)	157 ft
Time of concentration (Tc)	0.33 hrs
Lag Time (Lg)	0.20 hrs
Time to peak (Tp)	0.24 hrs
Peak Discharge (Qp)	625 cfs
Duration (D)	5 min.

<u>Time (Min.)(*)</u>	<u>Discharge (cfs)(*)</u>
0	0
5	151
10	498
15	618
20	494
25	275
30	158
35	89
40	52
45	29
50	17
55	9
60	6
65	3
70	1

(*) From the computer output

FORMULA USED:

$$T_c = \left(\frac{11.9 L^3}{H} \right)^{0.385}$$

From California Culverts Practice, California
Highways and Public Works, September 1942.

$$L_g = 0.6 T_c$$

$$T_p = \frac{D}{2} + L_g$$

$$Q_p = \frac{484 A \cdot Q}{T_p}$$

$$Q = \text{Excess Runoff} = 1 \text{ inch}$$

TABLE 2
RAINFALL-RUNOFF VALUES

<u>Selected Storm Event</u>	<u>Storm Duration (Hours)</u>	<u>Rainfall (Inches)</u>	<u>Runoff (Inches)</u>	<u>Loss (Inches)</u>
PMP	24	33.80	32.11	1.69

Additional Data:

- 1) Soil Conservation Service Soil Group C
- 2) Soil Conservation Service Runoff Curve CN = 86 (AMC III) for the PMF
- 3) Soil Conservation Service Runoff Curve CN = 72 (AMC II) for the
1 percent probability flood
- 4) Percentage of Drainage Basin Impervious 10 percent

TABLE 3
ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

<u>Elevation (feet-MSL)</u>	<u>Lake Surface Area (acres)</u>	<u>Lake Storage (acre-ft)</u>	<u>Spillway Discharge (cfs)</u>
900.5	0	0	
* 917.7	8.0	46	0
920.0	16.0	74	385
** 922.3	18.0	113	1600
925.0	20.5	165	
930.0	25.0	280	

*Primary spillway crest elevation

**Top of dam elevation

The above relationships were obtained from survey measurements and the ROLLA, MO. 7.5 minute quadrangle map.

TABLE 4

SPILLWAY RATING CURVE

<u>Reservoir Elevation (ft, MSL)</u>	<u>Spillway Discharge (cfs)</u>
917.7	0
918.7	74
919.6	250
920.0	385
921.0	800
922.0	1400
* 922.3	1600
924.0	3200
924.6	3900

* Top of dam elevation

METHOD USED: Assuming critical flow at the control section

FORMULA: $\frac{Q^2}{g} = \frac{A^3}{T}$ Design of Small Dams, Water and Power Resources
Service (U.S. Bureau of Reclamation), 1974 Edition,
page 553

Q = Discharge in cubic feet per second
A = Cross sectional area in square feet
T = Water surface width in feet
g = Acceleration of gravity in ft/sec²

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (CFS)	Peak Lake Elevation (ft.-MSL)	Total Storage (AC.-FT.)	Peak Outflow (CFS)	Depth (ft.) Over Top of Dam
	0	* 917.7	46	0	
0.10	359	919.1	63	154	
0.20	718	920.0	74	394	
0.30	1078	920.6	83	616	
0.40	1437	921.1	92	836	
0.50	1796	921.5	99	1094	
0.60	2155	921.9	106	1345	
0.65	2335	922.1	110	1479	
0.70	2515	** 922.3	113	1618	0
0.75	2694	922.5	117	1786	0.2
1.00	3592	923.1	128	2781	0.8

The percentage of the PMF that will reach the top of the dam is 70 percent.

*Primary spillway crest elevation

**Top of dam elevation

Sheet 7, Appendix C

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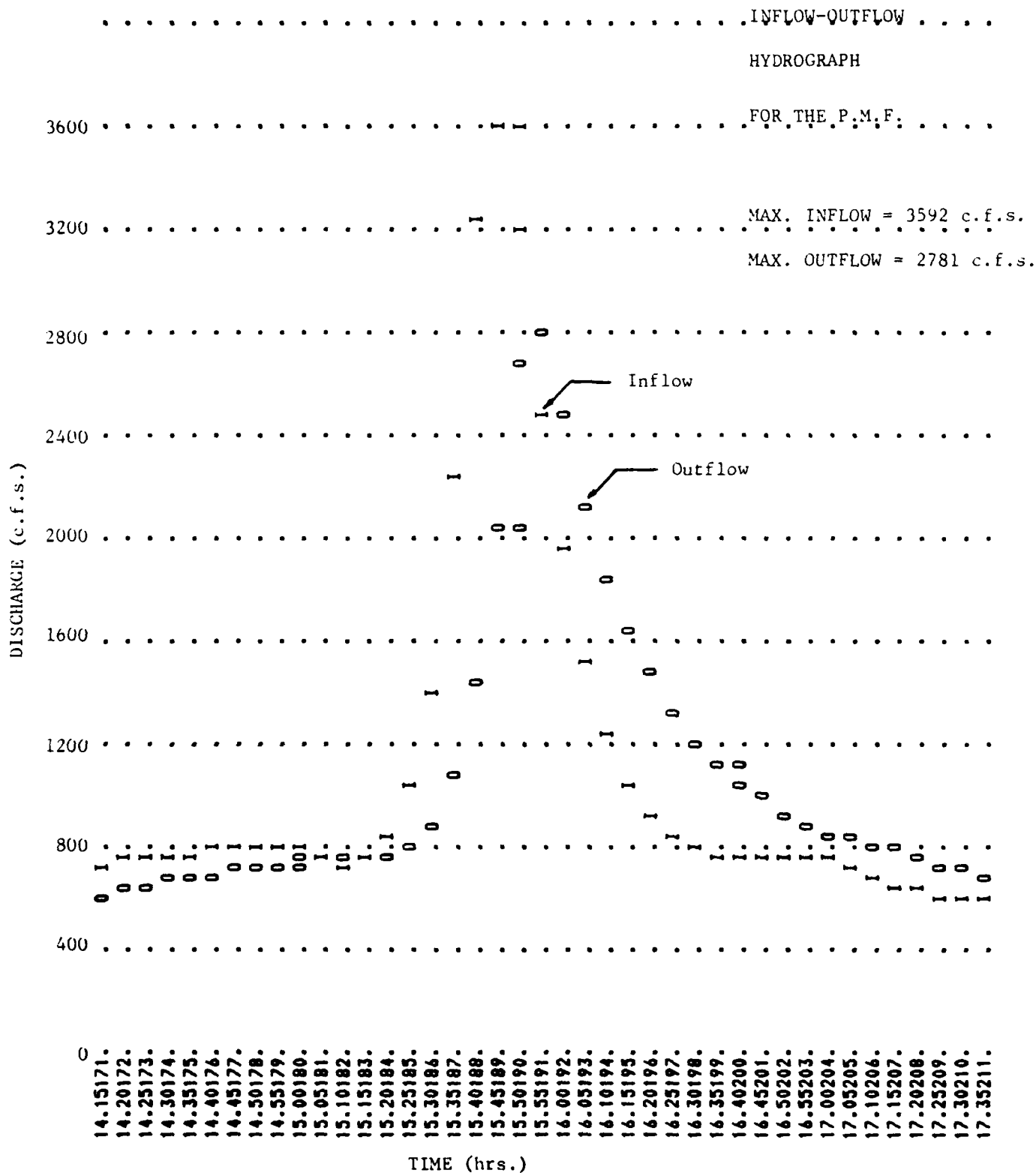
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

PMF RATIOS
OUTPUT DATA



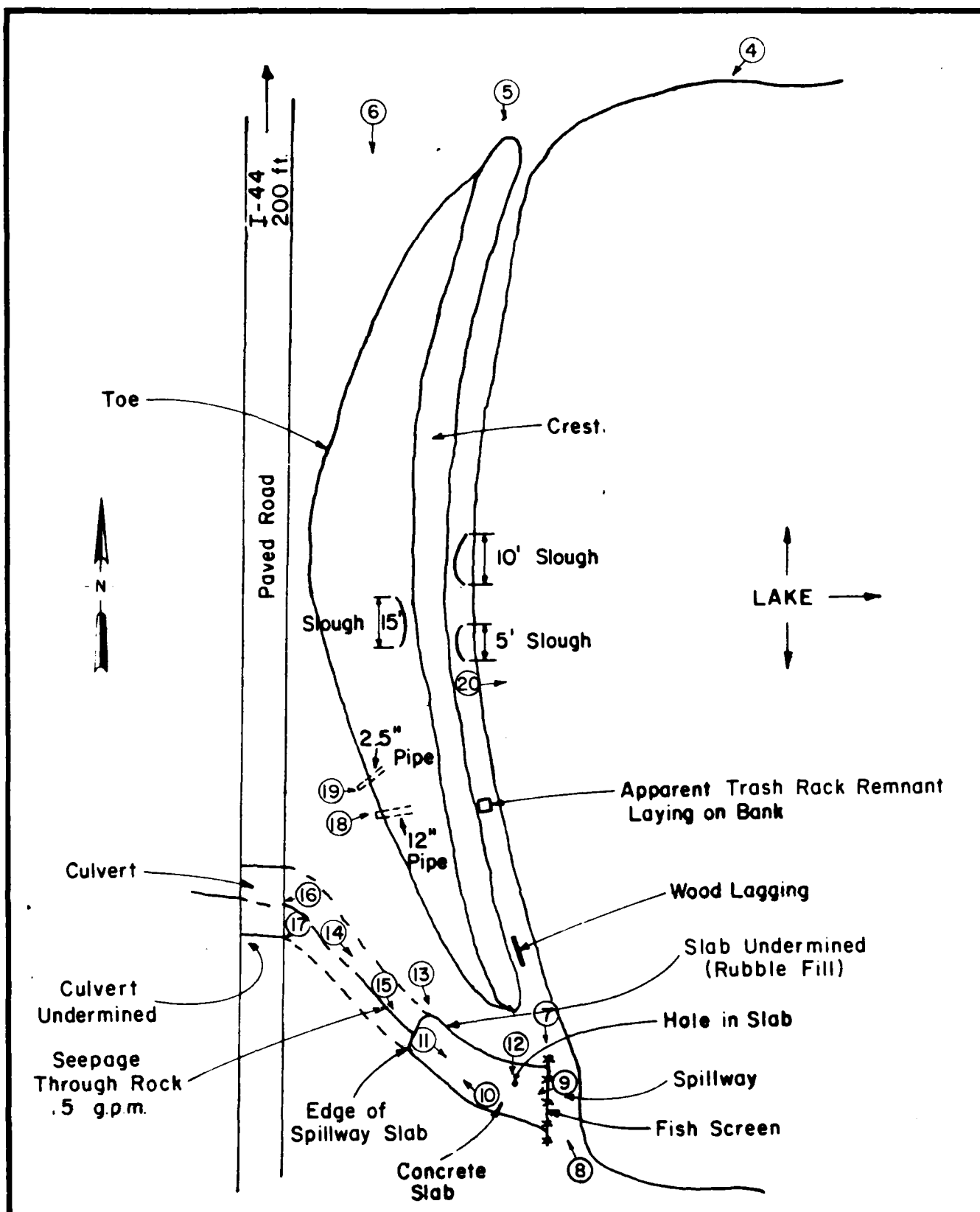
APPENDIX D

Photographs

LIST OF PHOTOGRAPHS

Photo No.

- 1 Aerial View of Dam Looking East
- 2 Aerial View of Lake and Dam Looking South
- 3 Aerial View of Lake and Watershed Looking Northwest
- 4 Upstream Face of Dam Looking Southwest
- 5 Crest of Dam Looking South from Right Abutment
- 6 Downstream Face of Dam Looking South from Right Abutment
- 7 Spillway Crest Looking South - Note Fish Screen and Walking Blocks
- 8 Spillway Crest Looking North
- 9 Spillway Looking Downstream From Crest
- 10 Spillway Channel Looking Downstream at Culvert Under Road
- 11 Spillway Looking Upstream From Downstream Edge of Paved Section
- 12 Spillway Slab - Note Hole in Concrete
- 13 Right Edge Spillway Slab - Note Apparent Erosion and Possible Undermining (Filled in With Rubble)
- 14 Spillway Channel Looking Upstream
- 15 Spillway Channel Near Lower Edge of Concrete Section - Note Small Trickle of Seepage Coming Through Bedrock
- 16 Culvert Under Roadway Looking Downstream
- 17 Undermining of Culvert Abutment Left Side
- 18 Outlet 12 in. CMP Under Dam
- 19 Outlet 2 1/2 in. Steel Pipe Under Dam
- 20 View of Lake From Crest



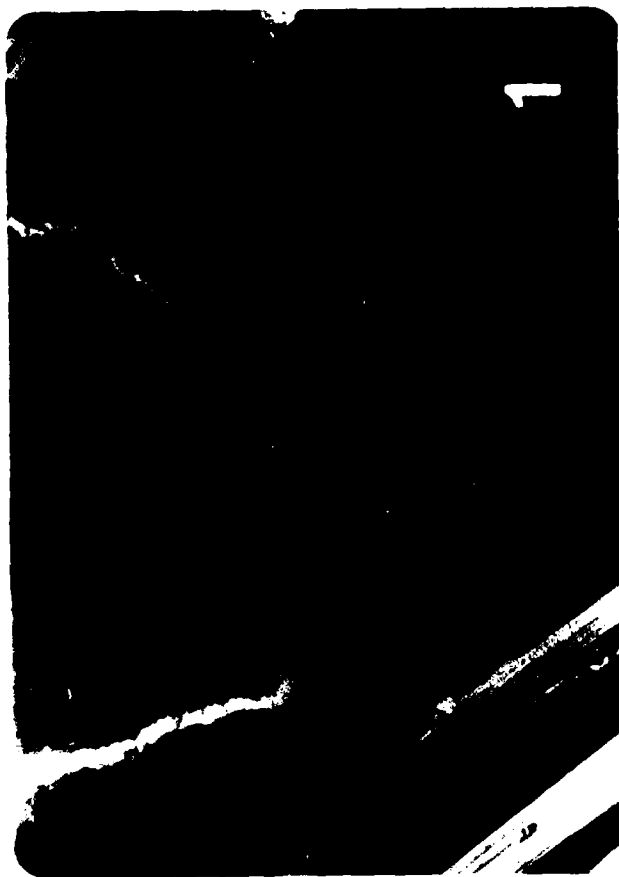
PHOTOGRAPH LOCATIONS



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Blues Pond Dam
Phelps County, Missouri
Mo. I.D. No. 31538

Sheet 2, Appendix D





6



8



5



